4.7 Funnel and Gate Treatment (FGT)

4.7.1 FGT-Alternative Description

4.7.1.1 General

Alternative #5 – Funnel and Gate Treatment (FGT) intercepts the CKD-affected groundwater on the east side of State Route 31 and passively funnels the water to an in situ treatment zone. After treatment, the water migrates through a subsurface discharge corridor and enters Sullivan Creek. FGT includes a system of subterranean slurry walls installed downgradient of the Closed CKD Pile. The slurry walls funnel water toward a central treatment zone, using the in situ neutralization technology discussed in Section 4.3.1. Subterranean gravel walls (French drains) on the upgradient side of the slurry walls help convey water along the slurry wall funnel to the treatment zone. The FGT gravel drainage layer components will help to conduct water to the treatment corridor. Although FGT is not a flexible alternative (i.e., once installed, the system cannot be moved), the FGT uses engineered subsurface components to gain control of the hydrogeologically complex area between State Route 31 and Sullivan Creek. Whereas PTW is prone to gaps in treatment, FGT treats water in a treatment corridor that reduces the potential for gaps. Exhibit 4.7-1 shows the conceptual layout of FGT.

4.7.1.2 System Description

The FGT description contained in this section is preliminary. System details may be modified during the design phase to enhance system performance. For example, slurry walls are a component of FGT that may be modified. Other impermeable materials such as high density polyethylene (HDPE) will be considered for use in the funnel, as will several different slurry compositions with various permeabilities and resistance to high pH water. FGT includes the main components described in this section. The FGT components are installed in a progression that begins near Sullivan Creek and moves upgradient. This construction sequence begins with installing the treatment zone and discharge corridor. Then the program builds other components that are designed to channel the upgradient water into the treatment zone. FGT general components include:

- ***Slurry Wall Funnel.*** Slurry walls[22] about 2 ft wide are constructed downgradient of the Closed CKD Pile. An earthen platform a few feet thick elevates the working surface above the shallow groundwater table. The increased slurry elevation within the platform area provides the vertical distance required to increase the pressure that the slurry will exert on the formation to reduce the potential for soil sidewall collapses and slurry wall voids. The slurry walls are aligned across the CKD-affected groundwater plume to capture and direct it to the treatment zone. The slurry walls key into the upper few feet of the low-permeability glacial sediments (i.e., clay) that underlie the Site at a depth of approximately 10 to 20 ft. The slurry composition, likely a bentonitic slurry, will accommodate high pH conditions.

- ***Gravel Wall.*** The gravel wall French drains are upgradient and within several feet of the slurry wall funnel walls. The gravel drains stop short of the ends of the slurry wall funnels to avoid the potential for CKD-affected water to migrate around the ends of the funnel. The approximately two-foot wide gravel walls key into the top of the low-permeability glacial sediments (i.e., clay) that underlie the Site at a depth of approximately 10 to 20 ft. They will be installed by excavating trenches and backfilling them with a biodegradable slurry to hold the trenches open. Gravel displaces the slurry as it fills the trench. Geotextile filter fabric will likely line the upgradient side of the gravel wall. The ground surface will be completed with a horizontal barrier to water percolation.

- ***Treatment Zone Side Walls.*** The depth of the treatment zone side walls is about the same depth as the slurry wall funnel. The treatment zone side walls will possess structural characteristics to allow bulk excavation of the treatment zone. The side walls will retain the soil outside the treatment zone. The treatment zone components are placed

[22] See Xanthakos (1979) for a very detailed description of the design, construction, and performance of slurry walls. ASTM (1985) includes numerous papers on slurry wall design, construction, and performance.

after the treatment zone is excavated and dewatered so that the full treatment zone is exposed and accessible.

- ***Treatment Zone.*** The treatment zone lies at the mouth of the funnel and consists of several in situ neutralization segments installed in series. The segments are built after the corridor is excavated in bulk and dewatered. The structural side walls allow maneuvering inside of the treatment zone, greatly improving the ease of constructability compared with the open water-filled trench encountered during Pilot System installation. Estimates show that five to seven segments provide sufficient treatment capacity.

- ***Discharge into Sullivan Creek.*** After treatment, water migrates through a subsurface discharge corridor to Sullivan Creek. Armoring the discharge location by using material that mimics the current rubble-strewn creek bank protects the creek bank from erosion.

- ***Performance Monitoring and Control Systems.*** Performance monitoring wells installed upgradient, between, and downgradient of the treatment segments evaluate the treatment system's performance. The data monitoring and delivery system design allows Lehigh to adjust the amount of treatment to meet cleanup standards without over- or under-treatment.

See Section 4.3.1.2 for discussion of the in situ treatment technology. Data from the Pilot System shows that pH is neutralized and that arsenic precipitates within the treatment zone. The rapid treatment that the Pilot System achieves supports the location of the treatment zone relatively close to Sullivan Creek.

4.7.1.3 System Performance

Although they may involve similar materials, the FGT slurry walls vary considerably from the ASC slurry walls in their construction, performance, and reliability. The FGT slurry walls are installed to relatively shallow depths using conventional excavation equipment, whereas the ASC slurry walls are installed to much greater depths using more cumbersome and complicated excavation equipment. ASC slurry walls are also installed along the toe of a historic landslide, unlike the FGT walls. To avoid activating the historical landslide by excavating a continuous trench, the ASC slurry wall is installed in alternating segments placed end to end. ASC slurry walls require detailed construction quality assurance procedures to install alternating segments without gaps between the segments, especially as depth increases. Conversely, FGT slurry walls are installed in a relatively open and flat space where trench collapses are less likely and could be controlled. Therefore, Lehigh has a significantly higher degree of confidence in the FGT slurry wall performance.

The FGT slurry wall funnel and gravel wall intercept CKD-affected groundwater and passively direct the water into an in situ treatment zone, where carbon dioxide neutralizes the high pH water. See Section 4.3.1.3 for a comparison of the different neutralizing agents that Lehigh considered. With the lower pH, arsenic in solution precipitates (i.e., forms insoluble complexes) in and immediately downgradient of the treatment zone. The discharge into Sullivan Creek from the treatment zone will meet cleanup levels for both pH and arsenic.

The FGT greatly reduces the concern over gaps in the PTW and provides a greater amount of hydraulic control.

On the upgradient side of the funnel, the gravel walls in the design of the FGT (see Exhibit 4.7-1) reduce the potential for water buildup in front of the slurry wall that could otherwise potentially overtop it. On the downgradient side of the funnel, water level fluctuations are relatively small because the upgradient dam at Sullivan Lake controls Sullivan Creek flow (Section 2.3.1). Under this fluctuation regime, water from Sullivan Creek will not overwhelm the discharge corridor and enter the treatment zone. The final design will accommodate these concerns.

4.7.1.4 Construction Schedule

FGT design, contracting, and procurement requires approximately eight months. FGT permitting and obtaining regulatory approvals requires approximately six months to one year (see Exhibit 3.2-1 for the list of permits and regulatory approvals). FGT installation requires approximately four to five months. Installation schedules for

FGT accommodate restrictions on construction in the vicinity of Sullivan Creek that permit such construction only during certain months of the year, July and August at the Site, to protect water resources. The winter temperatures and hours of daylight in Metaline Falls would adversely affect installation of the FGT. Although possible, construction of FGT during the winter months is not advisable.

4.7.2 FGT-Protect Human Health and the Environment

The FGT will protect human health and the environment for the following reasons:

- ***Groundwater Quality.*** The FGT will meet MTCA groundwater cleanup levels at a conditional POC. The Site-specific bench and pilot scale treatability studies [GeoSyntec, 2000, 2002, 2003a, and 2003b] demonstrated the effectiveness of the in situ treatment concept.
- ***ARAR Compliance***. FGT complies with ARARs.
- ***Institutional Controls***. Lehigh will use institutional controls as described in Section 4.2.2.

4.7.3 FGT-Comply With Cleanup Standards

The Site-specific bench and pilot scale treatability studies [GeoSyntec, 2000, 2002, 2003a, and 2003b] demonstrated the effectiveness of the in situ treatment concept. The FGT will meet cleanup standards assumed for the purposes of the Revised dFSTR, as follows:

- ***Cleanup Levels (CLs).*** The proposed groundwater cleanup levels for the Site are pH between 6.5 and 8.5, and maximum arsenic concentration of 5.0 ppb.

- *Point of Compliance (POC).* Lehigh proposes a conditional POC for groundwater at a point downgradient of the FGT treatment zone and upgradient of Sullivan Creek (Exhibit 4.7-1).

4.7.4 FGT-Comply With Applicable Federal and State Laws

The FGT complies with ARARs. Exhibit 3.2-1presents a summary of ARARs that apply to this alternative.

4.7.5 FGT-Provide for Compliance Monitoring

Lehigh will conduct protection, performance, and confirmation monitoring as described in Section 4.3.5.

4.7.6 FGT-Use Permanent Solution to the Maximum Extent Practical

4.7.6.1 Introduction

This element for selection of cleanup actions requires consideration of the criteria used in the disproportionate cost analysis (WAC 173-340-360(3)). Each criterion in the disproportionate cost analysis is discussed below.

4.7.6.2 FGT-Protectiveness

As described in Section 4.7.2, FGT will protect human health and the environment because it meets groundwater cleanup levels at a conditional groundwater POC. In addition, it complies with applicable state and federal laws. This alternative will not produce treatment residuals.

4.7.6.3 FGT-Permanence

Permanent Solution. FGT is not a permanent solution. The FGT requires indefinite maintenance, operation, repair and replacement, as needed.

Permanence. The FGT exhibits a high degree of permanence because it uses a treatment-based technology that obviates further treatment at the POC. The technology chemically neutralizes the high pH water, resulting in a permanent reduction in pH and lower solubility (mobility) and toxicity of arsenic. The FGT generates no treatment residuals. The FGT can dewater portions of the Closed CKD Pile under certain conditions. Dewatering the CKD also has a high degree of permanence because it reduces hazardous substance releases.

4.7.6.4 FGT-Cost

The estimated present value cost to design and install an FGT is approximately \$2.3 to 2.6 million (US \$2005) (see Exhibit 4.7-2). The annual operating and maintenance cost is estimated to be approximately \$150,000. Hence the present value of this alternative for 30 years at an annual discount rate of seven percent is approximately \$4.4 to 4.7 million. Actual costs may vary depending on the details of the final FGT system design and implementation procedures. Exhibit 4.1-7 includes the estimated costs of FGT for the three costing scenarios described in Section 3.2.3.2.3. See Appendix E for supporting information, including assumptions used in the cost analysis.

4.7.6.5 FGT-Effectiveness Over the Long Term

Lehigh will operate and maintain the FGT as long as needed to maintain compliance with cleanup standards. FGT groundwater control uses slurry walls, a primarily passive system. Slurry wall imperfections are expected to be less than for ASC because of the relatively shallow FGT target depths (see Section 4.7.1.3). FGT treatment is primarily a passive system, and because it incorporates a treatment technology that has proven successful at the Site, Lehigh has a high degree of confidence that it will be reliable over the long term. Lehigh will provide a financial assurance mechanism to cover the long-term operation and maintenance. The design allows Lehigh to add, replace, or remove FGT components over time, as needed, although the in-situ design poses some challenges. As such, the FGT is effective over the long term.

4.7.6.6 FGT-Management of Short-Term Risks

Few short-term risks are associated with FGT. Construction of the FGT has a potential for short-term exposure to high pH water, as is common with each of the alternatives. During FGT construction the potential exposure to high pH water occurs due to open trenches that will fill with water. Dewatering of the treatment zone during excavation and construction will reduce the potential for contact with CKD-affected groundwater. The water will be treated on-site prior to disposal or discharge. Workers will use heavy equipment and may relocate utility lines. Deliberate scheduling and protective measures will reduce the risks from the relatively rapidly flowing water when work occurs near Sullivan Creek. The risks posed are manageable with good construction safety practices.

Construction during the winter months will increase the short-term risks associated with FGT. Since the trenching operation is performed in saturated conditions, short or dim daylight periods increase safety concerns for workers. The winter conditions in Metaline Falls affect certain components of the FGT installation, specifically the perforated pipe installation in the treatment zone. Construction of FGT during the winter months is not advisable.

4.7.6.7 FGT-Technical and Administrative Implementability

4.7.6.7.1 Technical Implementability

As noted above, winter construction is not recommended for certain components. FGT is technically implementable during other times of the year.

4.7.6.7.2 Administrative Implementability

The FGT is administratively implementable. See Exhibit 3.2-1, which shows the permits and approvals needed for GWC. FGT requires an NPDES permit to discharge treated water into Sullivan Creek during construction and for long-term operation. Federal permits or regulatory approvals will apply to work along the banks of Sullivan Creek. Lehigh's research suggests that FGT will meet the conditions connected with these permits and approvals.

4.7.6.8 FGT-Consideration of Public Concerns

The public will be given an opportunity to review and comment on the dFSTR. Ecology will consider all public comments before finalizing the dFSTR.

4.7.7 FGT-Provide a Reasonable Restoration Time Frame

Although the alternative will clean up much of the groundwater, this alternative will not achieve clean up levels everywhere throughout the Site. Therefore, Lehigh proposes a conditional POC. It is difficult to precisely estimate when groundwater will meet the cleanup levels for pH and arsenic at the proposed conditional POC for groundwater. However, performance and confirmational monitoring allow Lehigh and Ecology to monitor progress. In addition, redundant systems, both for treatment and for performance monitoring, are designed into the FGT alternative to assist in achieving compliance and conducting compliance monitoring. The FGT achieves compliance with groundwater cleanup levels at a conditional POC in approximately the same time frame as other alternatives evaluated in this Revised dFSTR. The restoration time frame for FGT will be further refined during detailed design.

4.7.8 FGT-Consider Public Concerns

The public will be given an opportunity to review and comment on the dFSTR. Ecology will consider all public comments before finalizing the dFSTR.

4.7.9 FGT-Prevent Domestic Use of CKD-Affected Groundwater

Measures to prevent domestic use of CKD-affected groundwater are discussed in Section 4.3.9.

4.8 Partial Additional Source Control (PASC)

4.8.1 PASC-Alternative Description

4.8.1.1 General

Alternative #6 – Partial Additional Source Control (PASC) combines two remediation concepts: source control and downgradient in situ treatment. PASC supplements the FGT remedy with a gravity drain installed under the southern side of the Closed CKD Pile. The gravity drain is a source control technology that redirects unaffected groundwater away from the Closed CKD Pile, so that it will not contact the CKD. The gravity drain, working in concert with the FGT gravel drainage layer components will help to control the water flux within the floodplain alluvial aquifer. As the gravity drain redirects water to the FGT gravel layers and the gravel layers remove water by conducting it to the treatment zone, the groundwater surface may be lowered slightly within the alluvial aquifer. This control of the water flux within the alluvial aquifer has the potential to reduce a small amount of water in contact with the CKD under certain groundwater flow regime scenarios. This could reduce the volume of CKD-affected groundwater. The amount of downgradient treatment required will decrease with time as the gravity drain dewaters the area and as transient drainage through the CKD reaches an equilibrium condition. Exhibit 4.8.1 shows the conceptual layout of this alternative.

4.8.1.2 System Description

PASC combines the FGT components described above in Section 4.7 with a gravity drain. Lehigh will install a perforated drain pipe under the southernmost margins of the Closed CKD Pile using horizontal directional drilling techniques. The gravity drain will be installed at depths that mostly target water under the static groundwater levels observed in Monitoring Well MW-8 and PM-13, abandoned Monitoring Wells MW-5 and MW-6, and abandoned Piezometers P-2, P-7, and P-8 (See Exhibit 2.3-3). The southern side of the Closed CKD Pile presents the best opportunity to redirect clean water away from the Closed CKD Pile because much of the water passing through the Site enters via subsurface flow from the uplands south of this area. The gravity drain in this location also acts as a hydraulic control to reduce the potential for CKD-affected water to by-pass the southern edge of the slurry wall funnel. Because the gravity drain intercepts water before it enters the Closed CKD Pile, gravity drainage should meet water quality criteria for discharge into Sullivan Creek without treatment. The design will include the flexibility to convey the water to the treatment zone, if needed or desired.

The gravity drain will be installed as follows:

- Access the insertion point on the northern side of State Route 31 where the drainage will connect with the gravel wall of the FGT, if desired.

- Prepare the surface for drilling. This may include excavating a small pit for drilling, and preparing the insertion angle for the drill rods. Drilling begins in a down-angle direction before reaching target depth, at which point the hole traverses below the groundwater on the south side of the Closed CKD Pile.

- Directionally drill the pilot hole for the drain pipe in a location approximately shown on Exhibit 4.8-1. The hole will be installed at depths that are below the expected groundwater table, except for the upgradient side of the drain where it ascends sharply to exit the southern side of the Closed CKD Pile.

- The exit point may be completed in a surface monument or cut off and capped below grade. Lehigh will likely complete the drain in a manner that will provide future access to the pipe.

- Pull the perforated drain pipe back down through the pilot hole using the drilling equipment. Preliminarily, Lehigh estimates that the pipe will likely be 4-in. diameter, but it may be up to 6-in. diameter. Larger diameter pipes beyond 6-in. involve significantly more powerful and costly drilling methods to achieve the necessary boring diameter. Directing the placement of the drain is also harder with larger pipe.

- The pipe will not be perforated for a certain distance from the insertion point. The non-perforated section helps transmit the drained water to the FGT instead of allowing it to percolate back into the groundwater.

Exhibit 4.8-1 shows the conceptual layout of the PASC components.

4.8.1.3 System Performance

The gravity drain lies in the alluvium, between the CKD and the underlying clay aquitard. The gravity drain intercepts water flowing into the southern edge of the Site and conveys it near the southern tip of the slurry wall system. If the water requires treatment, the gravity drain empties it into the slurry wall funnel for eventual treatment.

Installation of the gravity drain under deep portions of the Closed CKD Pile is not recommended. The deep portions of CKD lie in areas associated with a higher density of large-diameter sediments than the southern side. Large size aggregate such as cobbles and boulders impede or stop directional drills. If a gravity drain was attempted in the deep area and intersected a deep portion of the CKD, the drain will not lower the water level below the CKD. Thus, it will not provide source control for the still submerged CKD. Furthermore, this CKD-affected water cannot be discharged into Sullivan Creek without treatment. The FGT component may not be equipped to handle the additional treatment burden, requiring substantial and impractical scale-up.

As discussed in Section 4.7, the FGT design addresses concerns related to water overtopping the slurry wall and to Sullivan Creek water entering the treatment zone during periods of high flow. The gravity drain may contribute more water to the slurry wall funnel than the FGT alone will contribute. The final design will accommodate these variables assuming the gravity drain location shown in Exhibit 4.8-1 is approximately where it will be installed.

The FGT component includes performance monitoring wells that measure groundwater treatment performance through the treatment system. This information allows Lehigh to adjust the amount of carbon dioxide delivered to the water and to comply with cleanup levels.

4.8.1.4 Construction Schedule

PASC design, contracting, and procurement requires approximately eight months. PASC permitting and obtaining regulatory approvals requires approximately six months to one year (see Exhibit 3.2-1 for the list of permits and regulatory approvals). PASC installation requires approximately four to five months. Installation schedules for the FGT component accommodate restrictions on construction in the vicinity of Sullivan Creek that permit such construction only during certain months of the year, July and August at the Site, to protect water resources. The winter temperatures and hours of daylight in Metaline Falls would adversely affect installation of the PASC. Although possible, construction of PASC during the winter months is not advisable.

4.8.2 PASC-Protect Human Health and the Environment

The PASC protects human health and the environment for the following reasons:

- ***Groundwater Quality.*** The PASC meets MTCA groundwater cleanup levels at a conditional POC. The Site-specific bench and pilot scale treatability studies [GeoSyntec, 2000, 2002, 2003a, and 2003b] demonstrated that the in situ treatment technology is effective.

- ***ARAR Compliance***. PASC complies with ARARs.

- ***Institutional Controls.*** Lehigh will use institutional controls as described in Section 4.2.2.

4.8.3 PASC-Comply With Cleanup Standards

The PASC will meet cleanup standards assumed for the purposes of the Revised dFSTR, as follows:

- ***Cleanup Levels (CLs).*** The proposed groundwater cleanup levels for the Site are pH between 6.5 and 8.5, and maximum arsenic concentration of 5.0 ppb.

- ***Point of Compliance (POC).*** Lehigh proposes a conditional POC for groundwater at a point downgradient of the PASC treatment zone and upgradient of Sullivan Creek (Exhibit 4.8-1).

4.8.4 PASC-Comply With Applicable Federal and State Laws

The PASC complies with ARARs. Exhibit 3.2-1 presents a summary of ARARs that apply to this alternative.

4.8.5 PASC-Provide for Compliance Monitoring

Lehigh will perform protection, performance, and confirmational monitoring as described in Section 4.3.5.

4.8.6 PASC-Use Permanent Solution to the Maximum Extent Practical

4.8.6.1 Introduction

This element for selection of cleanup actions requires consideration of the criteria used in the disproportionate cost analysis (WAC 173-340-360(3)). Each criterion in the disproportionate cost analysis is discussed below.

4.8.6.2 PASC-Protectiveness

As described in Section 4.7.2, FGT alone protects human health and the environment because it meets groundwater cleanup levels at a conditional groundwater POC. In addition, it complies with applicable state and federal laws. The gravity drain component of PASC reduces the amount of groundwater entering the Closed CKD Pile, thus limiting the volume of CKD-affected groundwater requiring treatment. This alternative will not produce treatment residuals that must be transported to a disposal facility.

4.8.6.3 PASC-Permanence

Permanent Solution. PASC is not a permanent solution. The PASC will have to be indefinitely maintained, operated, and replaced, as needed.

Permanence. PASC exhibits a higher degree of permanence than alternatives that rely solely on treatment for two reasons. The gravity drain intercepts water before it contacts the CKD, so that the water remains unaffected. This reduces the volume of hazardous substances generated at the Site. PASC also uses a treatment-based technology that chemically neutralizes the high pH water, resulting in a permanent reduction in pH and lower solubility (mobility) and toxicity of arsenic. The PASC generates no treatment residuals. The gravity drain has no moving parts and requires minimal maintenance. However, the in situ treatment zone requires maintenance, repair, and periodic replacement of parts.